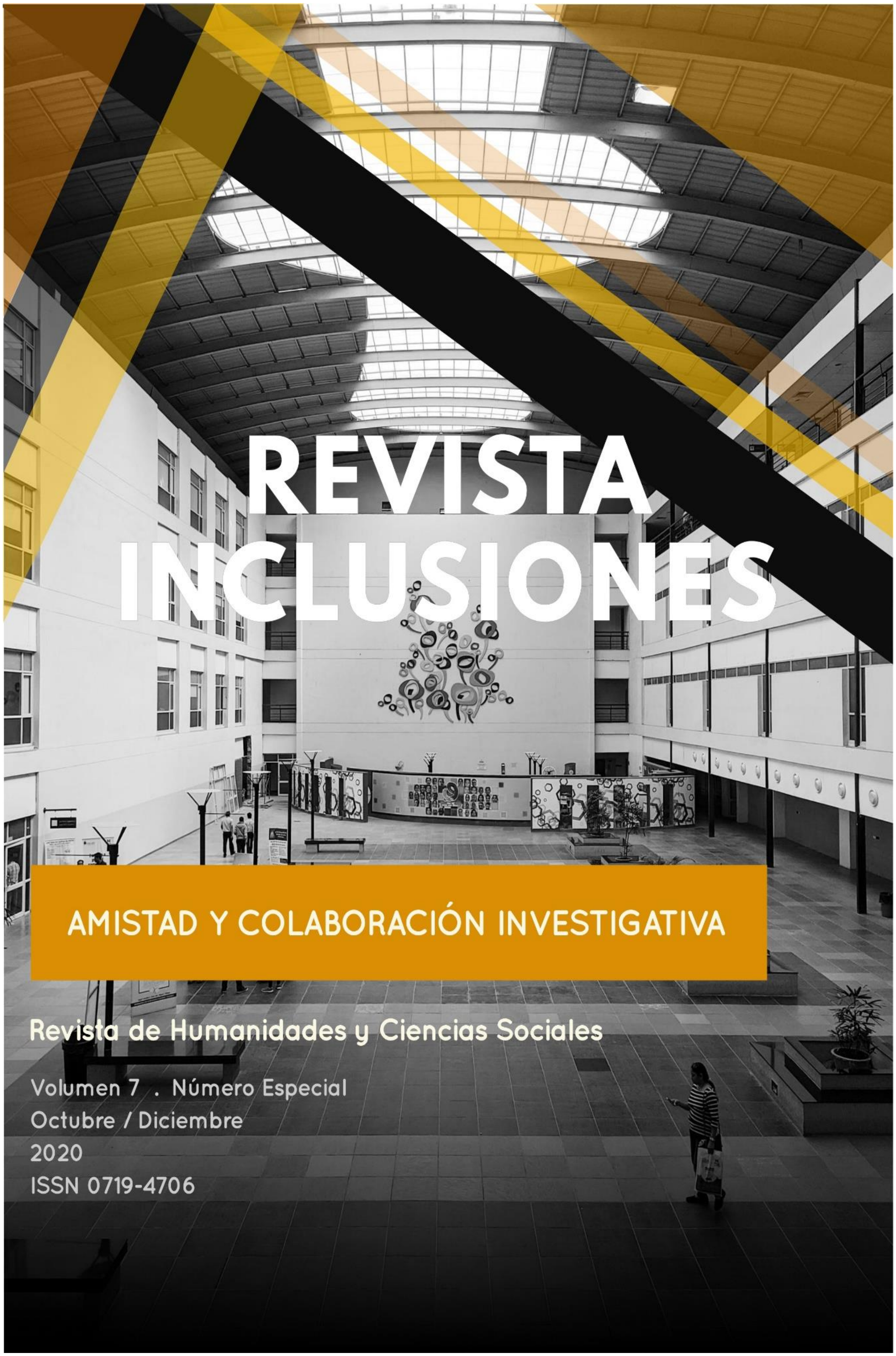

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DIGITAL TWINS IN INDUSTRY: BENEFITS AND TRAPS[1]

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Abstract

The article is devoted to the study of the economic and technological advantages of implementing digital doubles in industry. The analysis of digital twins' market growth trends in high-tech industries is conducted. Based on the analysis of successful practices of implementing digital twins in high-tech industries, the advantages of implementing digital twins in industry are presented and justified, based on the basic economic categories: quality, efficiency, costs, and profitability. It is noted that if the stage of predictive Analytics of digital engineering of digital twin design is a technological challenge for companies, it is important for economists to understand the essence of the increase in the effect of using digital twin. From this point of view, the use of digital twins is viewed through the prism of network effects that are generated with the development of digital platforms. The prerequisites for using the Metcalfe law in relation to digital twins are investigated, based on this law, it is possible to analyze the increasing utility of using digital twin technology: devices become "smarter" during operation. The authors point out that the law of increasing utility when using digital twins is associated with such pitfalls for business in the field of security: communication security; device protection; device control; control of network interactions; the closeness of the digital twin system; predictive security Analytics. Along with the considered security pitfalls, economic risks of implementation are highlighted, such as: high cost of implementation solutions, insufficient number of specialists in this field, lack of regulatory acts for the application and use of digital twin strategies. The analysis of the advantages and pitfalls of using digital twins in industry has led to the conclusion that the concept of digital twin is the most important tool for digital transformation of the industry. The success of creating technological superiority of companies in the market is largely determined by the level of technological innovation, the volume of consumer demand, as well as mechanisms for preventing digital piracy.

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Keywords

Digital twins – Digitalization of industry – Technological benefits – Economical benefits

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Introduction

The development of Industry 4.0 has an unprecedented impact on the dynamics of economic growth rates in various countries of the world. The use of emerging technologies in high-tech industries determines the strategic competitiveness of companies in the technology market. One of the breakthrough technologies that has a significant impact on the growth of value added in the industry is the Digital Twins technology[2].

Digital Twins technology is a set of dynamic digital or virtual copies of physical assets or products that is used in many industries to provide improved production structure, lower operating costs, increase system performance, and reduce product time to market (TTM). According to experts from Grand View Research, the size of the global Digital Twins market in 2017 was estimated at 2.26 billion us dollars, and it is expected to grow by an average of 38.2% between 2018 and 2025.

The UN report on the development of the digital economy identifies the key seven emerging technologies for the development of the digital economy: Blockchain technologies; Three-dimensional printing; Internet of Things; 5G mobile broadband; Cloud computing; Automation and robotics; Artificial intelligence and data analytics[3]. The implementation of Digital Twins is based on the use of artificial intelligence (AI), machine learning (ML) and the Internet of things[4].

The growing demand for connected devices across organizations, the increasing adoption of cloud platforms, and the emergence of high – speed network technologies allow businesses to choose IoT services for industrial and commercial solutions. Given that IoT allows businesses to develop Digital Twins platforms to improve the performance of services and processes, the growing adoption of IoT is particularly beneficial to the growth rate of the global technology market. At the same time, the vulnerability of IoT and cloud platforms to cyber-attacks and data security threats is holding back the growth of the technology market.

New projects can be tested in the virtual world, saving time, money, and resources. The digital twin can allow companies to solve physical problems faster by detecting them with a much higher degree of accuracy, design and create better products, and ultimately serve their customers better.

Methods

The research is based on analytical methods for collecting, analyzing, and interpreting data and analytical materials in the field of development and application of digital twins in high-tech industries. In addition, the benchmarking method was used in the analysis of best practices of international and Russian solutions based on the results of real projects.

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[2] R. Vrabiča; J. Erkoyuncu; P. Butala and R. Roy, “Digital twins: Understanding the added value of integrated models for through-life engineering services”, Procedia Manufacturing Vol: 16 (2018): 139-146. – Available at: https://doi.org/10.1016/j.promfg.2018.10.167 (date of access: 20.04.2020).

[3] Digital Economy Report 2019, “Value Creation and Capture: Implications for Developing Countries”. 2019. Available at: https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2466 (date of access: 11.03.2020).

[4] IBM-Industry Transformation with IBM Digital Twin, “IBM Watson IoT Connected Products Solutions”. 2018. Available at: https://www-01.ibm.com (date of access: 09.04.2020).

Digital transformation gradually covers all areas of industry, being an effective method of increasing production efficiency. One of the most promising in this direction is the creation of digital duplicates – virtual prototypes of a real object, group of objects or processes.

As part of digital twin technology, a mathematical model is created for a physical object, a piece of equipment, or an entire process, which is then used to analyze the behavior of the object. The model is constantly updated to match the operating mode of the actual installation as much as possible. This allows you to find deviations in processes, optimize equipment operation modes, and prevent breakdowns and accidents.

In Russia, the oil and gas and petrochemical industry has become the driver of the digital twin market development.

The engineering database contains all kinds of information about equipment and its relationships: the place of equipment in the production chain, standard operating modes, service frequency, geometric and technical characteristics, and much more. This system is also called EDMS (engineering data management system). Data is stored in it as a structure and linked to objects, which makes it easier to access them and allows automated processing.

The system allows you to significantly reduce the loss of time and the number of errors during maintenance, repair and ordering of spare parts. It also allows you to navigate through equipment for repairers, plan operations in advance for project repairs that are carried out every few years, including the system will tell you which parts of the equipment should be disabled or blocked in order to safely carry out repairs.

Technological modeling projects are developed in SIBUR, including based on the company's R&D center. In the process of creating a model or technological scheme of production, equipment is modeled, data on chemicals and indicators of the technological regime are entered. After checking the model, computational studies are performed and optimal process parameters are determined, and solutions are sought to improve technological and energy efficiency. The software allows you to calculate parameters such as energy, heat transfer, and even economic data: the cost of additional equipment, the feasibility of modernization.

Results and discussion

The study of the effects of Digital twins implementation in the industry determines the importance of understanding this term for the purposes of this article. Note that the essence of Digital twin is interpreted differently by representatives of the academic scientific community and business analysts. This term was first formulated in 2002 by NASA engineer John Vickers, and later used by M. Grieves in 2003. If M. Grieves studied the concept of “digital twin " in the field of product lifecycle management, then NASA's interest was in using digital twin technology to manage, maintain and repair physical systems in outer space. Created by NASA specialists, the Apollo 13 mirror system allows engineers and astronauts to determine the fulfillment of their tasks, considering the optimization of research and development costs. In fact, NASA used digital twin technology for the first time in space research when creating systems for the operation, maintenance, and repair of space equipment. Digital twin представляет собой “an appropriately synchronized body of useful information (structure, function, and behavior) of a physical entity in virtual space, with flows of information that enable convergence between the physical and virtual states”[5].

There are many definitions of a digital double. Table 1 shows the most common definitions, as well as their definitions authors.

Definitions	Author
Digital twin is an integrated multi-physical, multi-scale, probabilistic simulation of an assembled vehicle or system that uses the best available physical models, updates sensors, history, etc	Glaessgen & Stargel, (2012) [6]
A digital double is a real representation of all components in the product lifecycle using physical data, virtual data, and interaction data between them	Tao, Sui, Liu, Qi, Zhang, Song, Guo, Lu & Nee (2018) [7]
Dynamic virtual representation of a physical object or system throughout the lifecycle, using real-time data for understanding, learning, and reasoning	Bolton, McColl-Kennedy, Cheung, (2018) [8]
Using a digital copy of a physical system for real-time optimization	Söderberg, R., Wärmefjord, K., Carlson, J. S., & Lindkvist, L. (2017) [9]
A unified model of a real machine that runs on a cloud platform and simulates health status with integrated knowledge from both data-driven analytical algorithms, as well as other available one’s physical knowledge	Lee, Lapira, Bagheri, an Kao, (2013) [10]
A digital double is a digital copy of a living or inanimate physical entity. By connecting the physical and virtual worlds, data is transmitted imperceptibly, allowing the virtual entity to exist simultaneously with the physical entity	El Saddik, A. (2018) [11]

Table 1
Definitions of digital twins

As you can see, industry and academia define the digital double in different ways. However, perhaps none of the groups pays due attention to aspects of the digital twinning process. For example, according to one group, a digital double is an integrated model of a finished product that is designed to reflect all manufacturing defects and is constantly

[5] B. Hicks, “Industry 4.0 and Digital Twins: Key lessons from NASA”, 2019. Available at: https://www.thefuturefactory.com/blog/24 (date of access: 09.04.2020).

[6] E. Glaessgen and D. Stargel, The digital twin paradigm for future NASA and US Air Force vehicles //53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference 20th AIAA/ASME/AHS Adaptive Structures Conference 14th AIAA. (2012): 1818.

[7] F. Tao et al., “Digital twin-driven product design framework”, International Journal of Production Research num 1 (2018): 1-19.

[8] R. N. Bolton et al., “Customer experience challenges: bringing together digital, physical and social realms”, Journal of Service Management Vol: 29 num 5 (2018): 776-808.

[9] R. Söderberg et al., “Toward a Digital Twin for real-time geometry assurance in individualized production”, CIRP Annals Vol: 66 num 1 (2017): 137- 140.

[10] J. Lee; B. Bagheri and H. A. Kao, “A cyber-physical systems architecture for industry 4.0-based manufacturing systems”, Manufacturing letters. Vol: 3 (2015): 18-23.

[11] A. El Saddik, “Digital twins: the convergence of multimedia technologies”, IEEE MultiMedia. Vol: 25 num 2 (2018): 87-92.

updated to account for product wear. Other commonly used definitions describe a digital double as a digital model of a physical object with sensor support that simulates the object in real time. A digital twin can be defined as an evolving digital profile of the historical and current behavior of a physical object or process that helps optimize business performance.

We also want to note the difference between the concepts of digital double and digital shadow.

A digital shadow can be defined as a system of relationships and dependencies that describe the behavior of a real object, usually under normal operating conditions, and contained in redundant big data obtained from a real object using industrial Internet technologies. The digital shadow can predict the behavior of a real object only in the conditions in which data was collected, but it does not allow you to model situations in which the real object was not used.

The digital double is based on big data that is received in real time over a variety of dimensions. These measurements can create an evolving profile of an object or process in the digital world that can provide important information about system performance, leading to decisions in the physical world, such as changing product development and manufacturing processes.

In fact, a digital twin is a virtual copy of every physical object, device, machine, production, or industrial process that can be seen in a computer system.

Digital twin can exist at any stage of the lifecycle and aims to use elements of the virtual environment (high accuracy, multiphysics, external data sources), computational methods (virtual testing, optimization, forecasting), as well as elements of the physical environment (performance, customer feedback, cost, etc.) to improve product properties (performance, function, behavior, manufacturability, etc.).

The study of foreign experience in implementing Digital twins in the industry shows the growth of the prospects of this technology for business, mainly due to the complex application of artificial intelligence, machine learning and IoT technologies. According to IBM analysts ' forecasts, the digital twins market will grow by 37% annually by 2023. Figure 1 shows the growth trend of the Digital Twin market in the United States. According to analysts of Grand View Research, large-scale growth in the implementation of digital twins will be observed in high-tech industries, namely, in the automotive industry.

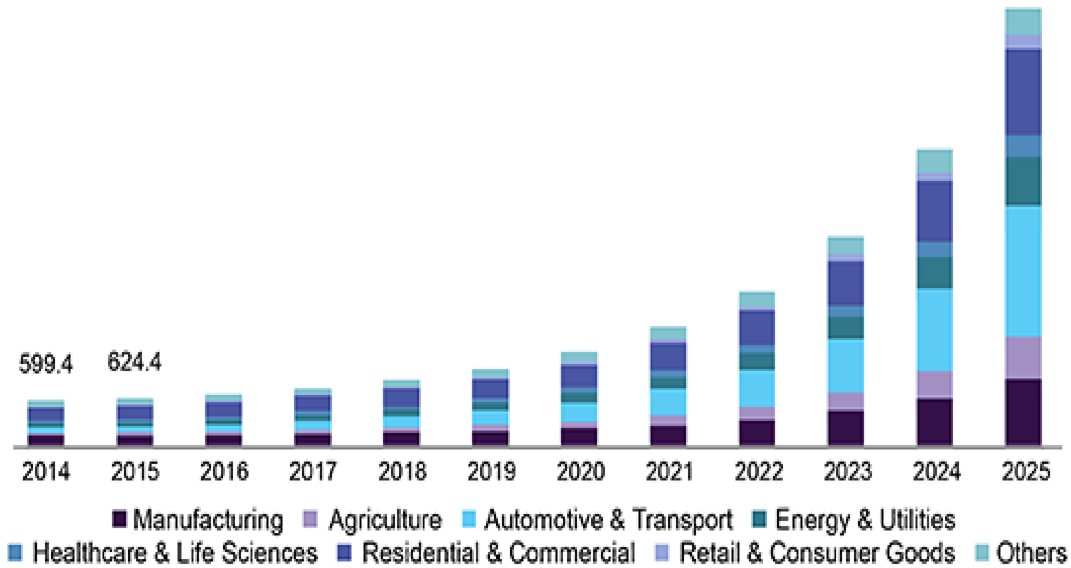

Fig. 1
U.S. Digital twin market size[12], by end use, 2014-2025 (USD million)
Source: Grand View Research, 2018

Companies use digital twin technology to take current operations to a new level of efficiency. Digital twins contribute to the testing of products before their launch and reduce problems with the risk to a minimum. The use of digital twins is carried out in almost all sectors of material and non-material production.

The digital double can be used for various purposes. First, this technology allows a deeper understanding of production processes. Digital twin also helps you quickly and accurately identify business problems by providing "reserved business development"[13]. This allows companies to speed up production and reduce their costs along the entire production chain, thereby optimizing their business. All changes that occur in a real device, machine, or system will be reflected in its digital model. This will ensure effective remote control of the object and allow you to detect equipment failures in advance or detect the beginning of its wear and tear in time.

According to a study by IDC analysts, by 2024, 50% of the companies included in the list of the world's largest public companies according to Forbes magazine will use digital doubles and ecoplatforms of digital doubles[14]. For rice. 2 presents the forecast of the digital technology market development for the period up to 2022, made by IDC.

[12] Digital Twin Market Size, Share & Trends Analysis Report. "By End Use (Automotive & Transport, Retail & Consumer Goods, Agriculture), By Region (Europe, North America, Asia Pacific), And Segment Forecasts. 2018 – 2025". (2018): 80. Available at: https://www.grandviewresearch.com/industry-analysis/digital-twin-market (date of access: 14.04.2020).

[13] A. A. Auzan, "Digital Twins, Digital Shadows and Digital Piracy", 2019. Available at: https://www.youtube.com/watch?v=Tx9Ws4680vM (date of access: 02.03.2020).

[14] L. Columbus, "IDC Top 10 Predictions For Worldwide IT", 2018. Available at: https://www.forbes.com/sites/louiscolumbus/2018/11/04/idc-top-10-predictions-for-worldwide-it-2019/#10e2c1ec7b96 (date of access: 11.04.2020).

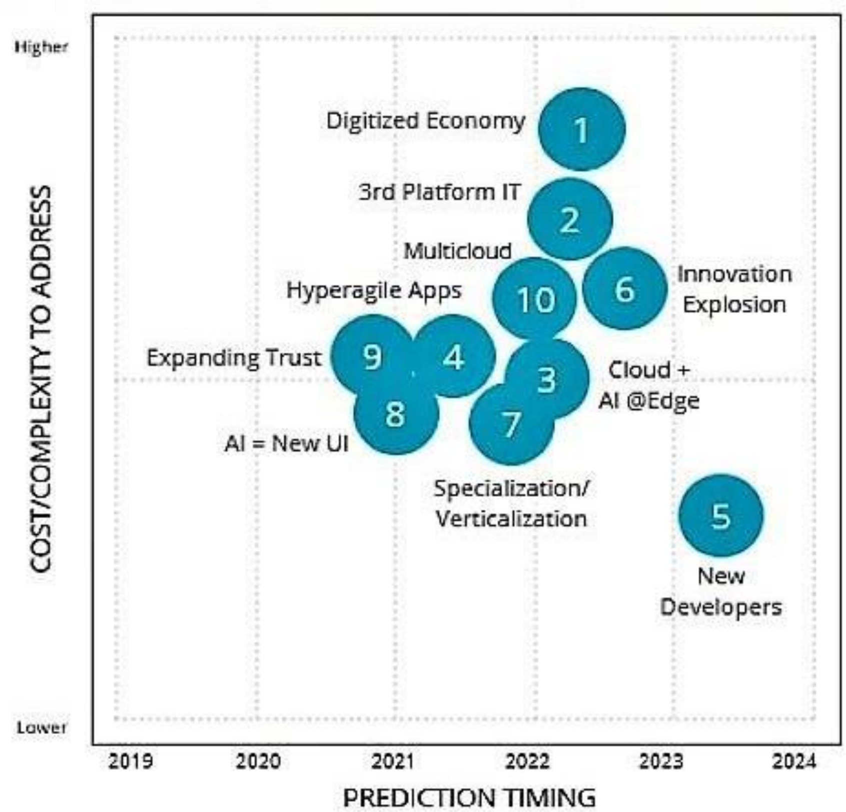

Fig. 2
IDC Future Scape: Worldwide IT Industry 2019 Top 10 Predictions
Source: IDC, 2018

According to the forecast (1) "Digitized economy" by 2022, the contribution of the digital economy to global GDP growth will be 60%. At the same time, the growth of each industry will be driven by the digital expansion of offerings, operations and platforms, primarily through digital twin technology. Forecast (2) "Digital-native IT" assumes that by 2023, 75% of all IT spending will be carried out on the 3rd Platform technologies. Moreover, 90% of all enterprises create their own digital IT environments to ensure technological superiority in the market. One of the ways to create such an IT environment is digital twin technology. Consider the successful implementation of digital twins in high-tech industries. The German concern Siemens actively uses digital twin technology in the process of nonlinear product modeling. An effective platform solution for the company is the Digital Enterprise Suite based on Digital Twin technology, which allows you to integrate software and automation on a Central data platform to optimize production processes of any complexity. Siemens pays more attention to production processes, for which, in particular, virtual commissioning technologies are used, which make it possible to test the functioning of production lines and facilities before commissioning, and after working out various options, choose the best one [15].

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[15] Digital twins in the high-tech industry. "Expert and analytical report". M.: Technet. 2019. Available at: http://assets.fea.ru/uploads/fea/news/2019/12_december/28/cifrovoy_dvoinik.pdf (date of access: 24.04.2020).

The latest digital Twin cloud technology is ITwin, developed by Bentley Corporation. ITwin services allow the company to create, visualize and analyze digital twins of infrastructure projects and assets. ITwin Services links digital engineering BIM design tools and multiple data sources, achieving 4D digital twins visualization. This records engineering changes within the asset plan / project to ensure a complete record of the process (who made the changes and when). Engineering teams use iTwin services to inspect and validate design data and generate knowledge. Users of Bentley design programs can use the iTwin Design Review service to review ad hoc design, and project teams using ProjectWise can add the iTwin Design Review service to their digital workflows to implement digital twins more effectively[16].

Note that Bentley Systems and Siemens have jointly developed the PlantSight platform, which allows business owners to create digital twins of operational processes for a long-term period. According to Bentley experts, the long-term use of such digital twins is determined using P&ID models, 3D and IoT data.

In the field of electric power industry, we will present the successful practice of using digital twin technology by the French company RTE, which is the system operator and operator of main networks in France. To manage its assets, RTE has chosen the MONA management model based on the creation of digital twins. The MONA program can model strategies for managing all the operator's assets in the short, medium, and long term. Digital twins reflect each asset in the network, for example, a substation with its specific dynamics, the need for maintenance and updating, the number and cost of operations, depending on the specific case.

In Russia, the center for computer engineering (CompMechLab ®) of Peter the Great Saint Petersburg Polytechnic University is the leader in the field of digital design and simulation of digital twins. A team of scientists and business representatives created a single platform for the Aurus family of cars-the "Tuple" project. The design was performed on the basis of a specialized digital platform CML-BenchTM using digital twin technology[17]. The implementation of the project allowed creating a single modular platform for designing the bodies of limousines, sedans, minivans and SUVs intended for transporting and accompanying top officials of the state, as well as other persons subject to state protection.

In table. 2 presents the advantages of implementing digital doubles in industry, based on the basic economic categories. When determining potential advantages, we proceeded from the direction of technological innovations and business innovations in the production sector.

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[16] Bentley, "Digital Twin Cloud Services for Infrastructure Engineering". 2019. – Available at: https://www.bentley.com/en/products/product-line/digital-twins/itwin (date of access: 08.03.2020).

[17] A. I. Borovkov, "Kortezh" passed 50,000 virtual crash tests. 2018. Available at: https://nti2035.ru/media/publication/aleksey-borovkov-kortezh-proshel-50-tysyach-virtualnykh-krash-testov (date of access: 11.03.2020).

Categories	**Potential benefits of digital engineering**	
	Technological	**Economical**
1	**2**	**3**
Quality	- improving the overall quality of products; - total control over the technological chain of product production; - virtual simulation of production scheduling (based on information from MES / ERP systems); process data collection; research, development and design (including information from CAD/CAM/CAE); production management; maintenance management.	-foreseeing the quality level of products and preventing defects; - forecasting trends in the level of quality and readiness to solve problems. – virtual simulation to control the consumption of materials and energy; processing of orders; -forming requests for procurement items; inventory control of material resources; documenting and accounting of the client's requirements; organizing the shipment of products; inventory control of finished products; recording and working with enterprise standards.
The cost of producing a new product	- reducing the cost of producing a new product; – definition of component production in the long term and the impact on the supply chain;	- creating new business opportunities; -reduced time to market for a new product; - virtual modeling of the analysis of efficiency and costs of production; preparation and distribution of statements of product defects by company services.
profitablenes s	- identification of products that need to be updated; – getting information to improve virtual models; - understanding the current hardware configuration for high-performance maintenance.	- creating new sources of income; -increasing product/service differentiation; - increasing the efficiency and cost of the service product; -comprehensive product lifecycle management; - proactive identification of customer guarantees and claims.
Efficiency	– increased flexibility of production; – improving the efficiency of process management; – high technical availability of equipment; - predictive Analytics of equipment failures, timing of equipment wear and tear; - commit serialization; - collection and analysis of operational data.	- improving the efficiency of the production system; - creation of digital serialization records for elements and raw materials in order to meet the requirements for tracking the process more quickly; - operational regulation of compliance with the requirements of guarantee obligations to stakeholders

Table 2
Advantages of implementing digital doubles in the industry
Source: Authors' approach

The analysis of advanced foreign and Russian experience in implementing digital twins in the industry allows us to conclude that the current challenge for business is a clear understanding of the benefits of investment in the creation of a digital twin and the mechanism of influence of this technology on the revaluation of business value. When considering the economic effects of implementing digital twins, companies should focus on issues related to strategic performance and market dynamics. Important benefits of implementing digital twins are improved product quality and lifetime, faster product design cycle, planning for new revenue sources, and better cost management. These strategic advantages can be translated into specific programs that digital twin technology can implement.

Note that most IoT providers are very interested in implementing digital twins. Almost every IoT platform contributes to the implementation of certain features for digital counterparts, although there are differences in the timing of their testing[18]. The digital counterpart in the IoT belongs conceptually to the next generation of networks, so its architecture is very similar to the well-known NGN architecture. The digital twin consists of a set of different infocommunication technologies that enable The IOT to function, and its architecture shows how these technologies are related to each other.

Thus, one of the strategic advantages of implementing digital twins is the continuity of digital technological monitoring of product production processes throughout the production chain, which directly leads to optimization of production costs and promotion to the market. However, the most important technological aspect of ensuring the company's strategic competitiveness is the predictive design stage, which will ensure the company's reserved development in the long term.

If the predictive Analytics stage of digital engineering of digital twin design is a technological challenge, then it is important for the economy to understand the essence of the increase in the effect of using digital twin. From this point of view, consider the use of digital twins through the prism of network effects that are generated with the development of digital platforms.

Generating network effects is directly determined by the possibility of winning by all participants in the network[19]. Thus, each subsequent network member can increase the network's usefulness to other network members. When studying the network effect, it becomes clear that the network effect increases when a critical number of users of a product or service, or the so-called "critical mass", is reached. As R. points out Nureev, "the principle of increasing utility in the network leads to a paradoxical phenomenon, from the point of view of traditional microeconomics, when the network becomes "more interesting" for its participants with increasing numbers018). This dependence, known as B. Metcalfe's law, shows that the utility of a network is proportional to the square of the number of its users[20].

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[18] J. Gubbi; R, Buyya; S. Marusic and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions", Future Generation Computer Systems Vol: 29 num 7 (2013): 1645–1660.

[19] S. A. Djatlov, "Networking effects and increasing benefits in the information and innovation economy", Izvestiâ Sankt-Peterburgskogo gosudarstvennogo èkonomičeskogo universiteta, num 2 (86) (2014): 7-11.

[20] B. Metcalfe, "There Oughta Be a Law", The New York Times, 15 July 1996, (1996) Available at: https://archive.nytimes.com/www.nytimes.com/library/cyber/week/0715laws.html#metcalfe (date of access: 20.04.2020).

Using the Metcalfe law in relation to digital twins allows us to note the increasing utility of using this technology, which makes digital twin become "smarter" in the process of operation.

The manifestation of network effects is closely related to the formation of network benefits. Network goods are characterized by the following properties: the complementarity property; the property of significant economies of scale of production; the property of network external effects; the property of trap effects [21].

Let's focus on each of these properties. Complementarity as a property of a network good means that a particular good is used in conjunction with other benefits of the network. Note that consumers do not purchase a single good, but elements of a single network of which they are members. In this regard, when forming a network, a significant share of costs falls on the initial stage of production of network goods. At the same time, the cost of producing the first copy of the good is very high. This, we emphasize, is the main contradiction between neoclassical theory and the foundations of the development of the digital economy. If, according to neoclassical economic theory in long-term use goods, the law of diminishing utility, then in the digital economy for a long period of use of network goods leads to an increase in utility and revenue.

As for the economies of scale in the study of network effects, taking into account the fact that the good increases its value exponentially in the network, even small and medium-sized enterprises have the opportunity to get a certain benefit by creating many different economic units.

Despite the criticism of Metcalf's law by scientists B. Briscoe, A. Odlyzko, and B. Tilly regarding the inaccuracy of predicting the growth of network utility[22], however, this law remains an important tool for setting goals in the process of developing innovations.

When considering the economic benefits of implementing digital twins based on the study of network effects, it is important to pay attention to the emerging institutional pitfalls when using digital twin technology. The study of the network effect of the trap is presented in the work of American economists C. Shapiro & H. Varian, who drew attention to the fact that in modern networks, customers are "caught" by the terms of previously concluded contracts, which are usually quite difficult to terminate. Moreover, they are "caught" by the network's operating conditions [23]. The nature of network traps is closely related to the action of a number of persistent ineffective patterns of behavior that cause the action of institutional traps. In the theory of institutional traps, we are talking about a special case of a plurality of stable equilibria that occurs in a community of economic agents who choose a norm of behavior. An institutional trap is an equilibrium in which agents have chosen a norm of behavior that is ineffective compared to another norm that is also equilibrium under the same external conditions[24].

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[21] R.M. Nureev, “Digital economy: on the eve of fourth industrial revolution?”, Theoretical economy Vol: 6 num 48 (2018): 70-73.

[22] B. Briscoe; A. Odlyzko and B. Tilly, “Metcalfe’s Law Is Wrong. IEEE Spectrum”, 2006. Available at: http://spectrum.ieee.org/computing/networks/metcalfes-law-is-wrong (date of access: 11.03.2020).

[23] C. Shapiro and H. Varian, Information rules: A Strategic Guide to the Network Economy (Boston, Massachusetts: Harvard Business School Press, 1999).

[24] V. M. Polterovich, Elements of the theory of reforms (Moscú: Ekonomica, 2007).

The process of forming and stabilizing the emergence of institutional traps is carried out under the influence of a coordination mechanism, a learning mechanism, a coupling mechanism, cultural inertia and lobbying. Coordination and learning mechanisms are important in blocking technological development[25]. The mechanisms for creating and anchoring norms directly cover three different spaces: the norm space, the agent space, and the time space[26].

The law of increasing utility when using digital twins involves such institutional pitfalls as cybersecurity, data interoperability, and communication quality. The essence of the "cybersecurity" trap is that the more the network effect of using digital platforms increases,the higher the requirements for data storage security should be.

The analysis of foreign and domestic experience in implementing digital twins allowed us to identify the following pitfalls for business in the security sector:

1. The security of the connection.

1. Secure storage of IoT-related data. The communication channel must be secured, which requires the use of new cryptographic technologies, in particular, ECC (Elliptic Curve Cryptography). An equally important task is to manage keys to verify the validity of data and the reliability of the channels for receiving it. Leading certification authorities embed "device certificates" in IoT devices, allowing authentication of a wide range of devices, including cellular base stations, and others.

2. Protection devices.

It is necessary to ensure the protection and integrity of the IoT program code. Signing the code is necessary to confirm the validity of its launch, execution of the code during loading. Signing the code with a cryptographic key ensures that it will not be broken after signing and will be secure for the device. This can be implemented at the application and firmware levels, even on devices with monolithic firmware. The efficiency of the host record is also required. Host protection allows you to conduct audits and alerts, track logs and actions,and provide security.

3. The device control.

Conducting reverse engineering on the basis of the configuration update; control telemetry of security intelligence security. Moreover, telemetry management is required to monitor the correct functioning of devices, diagnose and restore, and manage network access credentials.

4. Control of interactions in the network.

Device certificates can contain information about the origin and type of device. However, this creates a trap of trusting the device manufacturer, its reputation, and access to the catalog. In fact, each digital twin is surrounded by a large number of devices.

[25] W. B Arthur; P. W Anderson; K. Arrow and D. Pines, "Self-Reinforcing Mechanisms in Economics", The Economy as an Evolving Complex System (Santa Fe: Addison-Wesley Publishing Company, 1988).
[26] G. B. Klejner, Evolution of institutional systems (Moscú: Nauka, 2004).

At the same time, directories allow you to understand devices that play an important role for the user. The directory concept makes it possible to quickly search for a remote device through the directory and helps speed up the decision to use data from other devices.

5. The closeness of the system digital twin.

Most digital twins are closed systems. Device consumers cannot modify or improve security software after selling finished products. Such interference with the part of the consumers, especially, will void the warranty. For this reason, the protective functions must be built into the device from the very beginning.

6. Predictive security Analytics.

Security Analytics can use device and network hardware security telemetry to provide a clear picture of what is happening in the computing environment, including detecting hidden threats. The same data is used in analytical systems as part of solving problems of optimizing the operation of the digital double. Monitoring and Analytics can often be deployed as a temporary solution in environments where other security features take a long time to deploy.

Along with the security pitfalls of using digital twin technology, it is also necessary to note the economic risks of implementation, such as: high cost of implementation solutions, insufficient number of specialists in this field, the lack of regulatory acts for the application and use of digital twin strategies.

Conclusions

The analysis of the advantages and pitfalls of using digital twins in industry leads to the conclusion that the concept of digital twin is an important tool for digital transformation of the industry. The success of creating technological superiority of companies in the market is largely determined by the level of technological innovation, the volume of consumer demand, as well as mechanisms for preventing digital piracy. Russia has significant key competencies in the field of design, modeling, testing, production and operation of products and products, which will form a national market for digital doubles.

One of the most important directions of digital transformation of the Russian industry is state support for stimulating consumer demand in the technology market, taking into account the increasing effects of using digital doubles in ensuring the strategic competitiveness of industrial enterprises.

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